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PHYSIOTHERAPY - AGE-RELATED CHANGES IN PHYSICAL FUNCTIONING: CORRELATES BETWEEN OBJECTIVE AND SELF-REPORTED OUTCOMES

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ABSTRACT

Objectives: Firstly, to quantify the variance attributable to age and estimate annual decline in physical function and self-reported health using a battery of outcome measures in healthy older females. Secondly, to determine whether self-reported functional losses are similar to those measured objectively and which best represent overall physical capacity.

Design: Experimental study, cross-sectional analysis.

Setting: Human Performance Laboratory, University setting.

Participants: Thirty-nine community-dwelling women (Mean[SD] age=71.5[7.3]years, range 60-83years) completed a battery of *objective* measures of function and a *self-reported* health status survey.

Intervention: None.

Main outcome measures: *Objective measures:* Gait speed; TUG test; sit-to-stand; concentric knee flexor and extensor moments; *self-reported*: the SF-36.

Results: Using a cross-sectional approach, annual declines were estimated for: TUG time (2.1%); gait speed (1.2%); knee extensor (2.2%) and flexor moments (3.0%); and *self-reported* Physical Functioning (0.9-1.2%) ($p \leq .001$). Linear regression indicated that age explained moderate variance in the *objective* (R^2=21-34%) and *self-reported* (R^2=14-28%) outcomes. TUG time and gait speed was significantly correlated with all *objective* outcomes except sit-to-stand (r=0.46-0.83) and most of the *self-reported* (r=0.10-0.63) outcomes ($p<.01$).

Conclusions: Age-related functional deterioration was estimated precisely across both objective and self-reported outcomes. Greater strength losses for the knee flexors compared to the extensors indicate an unequal strength loss of antagonistic muscle pairs which has implications for the safe completion of many functional tasks including obstacle negotiation, stair locomotion, postural transitions, and ultimately knee joint stability. Furthermore, walking speed and TUG time correlated most strongly with many of the outcomes highlighting their importance as global indicators of physical capacity.

Keywords: healthy ageing; objective and self-reported outcomes; physical capacity; functional performance

INTRODUCTION

The ability to perform common activities of daily living (ADL) autonomously is essential for independence and mobility. However, as we age, a combination of physical and psychological changes reduces our ability to complete these daily tasks(1-6). This may lead to increased sedentary behaviour, task avoidance and ultimately poorer quality of life(7). Government statistics have confirmed that adults ≥65 years have an increased life expectancy(8). Therefore, monitoring physical function within healthy older populations is critical to facilitate the early identification of decline and offer insight into the age-related loss of physical function and general health. Accordingly, the Chartered Society of Physiotherapy (CSP) has recommended that normative data for healthy older adults should be documented regularly as it provides a baseline from which age-related dysfunction may be identified(9). Furthermore, the Australian Physiotherapy Association have suggested that continued documentation is vital for monitoring, evaluating and justifying patient care(10).

An individual's ability to perform ADL can be monitored using a range of measured and self-reported outcomes(2, 3, 11). These assessments are often simple to perform, are appropriate for use with older adults(12) and individuals at risk of falling(13). Consequently, such "outcome measures" are routinely used in physiotherapy, rehabilitation, occupational and geriatric settings(14) where they provide information about functional mobility(15), prospective falls risk(16), and offer moderate-to-good test-retest reliability(16, 17). Objectively measured functional losses (gait speed, chair-stand time, grip strength, and balance) correlate moderately with self-reported functioning (r ranged from -.19 to-.63, p<.05)(18), and gait speed appears to be a global indicator of function over a broad range of capacities(18). Selecting the most appropriate battery of outcomes can be challenging for health professionals and is often dependent on the population of interest, the nature of the visit (i.e., routine check-up, hospital admission), and the equipment/expertise available.

Existing evidence originating from segmented age-group comparisons (ie. according to decade 60-69y, 70-79y etc) suggests that physical function worsens as older age ensues and that the decline is linear(2, 3, 5, 6), but the year-on-year progression of this deterioration is less defined. For example, the time taken to complete the 'Timed get-Up and Go' (TUG) test increases by ~40% (8.1–11.3s) between the ages of 60-99years(3) but the annual rate at which declines occur is less clear. Similar limitations in our knowledge exist with regards to the sit-to-stand (STS) task(4, 5). Comfortable gait speeds gradually slow with advancing age(19), and grouped means suggest that greater declines occur >79years(1). Lower limb strength decreases continuously across intervals of older age(20) with a 19% loss in knee extensor strength reportedly occurring across the 8th decade(21). Age-related changes in the SF-36 sub-scales indicate that, in general, the physical components deteriorate while the mental components remain constant or show small increases across age-grouped samples(22). However, these data do not include adults aged over 64 years, thus restricting generalisations to older populations. Very few studies have attempted to quantify annual losses in physical function, meaning subtle yet important changes may be overlooked when age-related decline is generalised from wide pre-defined sub-divisions of old age. Moreover, evaluating functional changes across broad age ranges makes it difficult to monitor functional decline across a shorter period of time and may mean that the optimal time to intervene could be missed inadvertently.

The few previous studies that have quantified annual changes have solely focused on the age-related change in functional performance in isolation such as muscle strength(21, 23), balance(24), measures of walking speed(25), and self-reported physical function only without substantiating objective measures(26). Moreover, TUG time has been used to estimate changes in a single(14) or a battery of outcomes (comfortable and fast gait speed, balance, TUG, STS, 6-minute walk time, and physical performance test)(1). Whilst the authors presented a range of measures, the study used both age and the use of an assistive device to understand age-related decline(1). Understanding the subtle nature of these losses that occur across the older age spectrum in a battery of outcomes will guide timely intervention to attenuate functional decline.

The aims of this study were to: (i) quantify annual changes in physical function in a convenience sample of healthy, older community-dwelling women across a battery of clinical outcomes; and (ii) to determine whether self-reported functional losses are similar to those measured objectively and which outcomes best represent overall physical capacity. It was hypothesised that linear relationships would exist between physical function and age with minimal annual (year-on-year) changes expected in self-reported well-being, throughout the age spectrum.

METHODS

PARTICIPANTS

Thirty-nine healthy, community-dwelling older women (Mean age[SD] 71.5[7.3] years, height 1.63[0.07]m, mass 70.6[12.4]kg) with no prior falls history gave written consent to participate in this study which was approved by the local NHS Ethics Committee (08/H1305/91). This work forms part of a larger set of studies that evaluated the influence of healthy ageing on the biomechanical profiles of ADL (27, 28). Due to technical failure during data acquisition, missing data were recorded for the STS test (n=37 remaining) and knee dynamometry (n=35 remaining).

OUTCOME MEASURES

The TUG and the STS tasks were assessed using the same standard chair with no arm rests (seat height:46cm, depth:38cm, and back height:74cm)(14, 15). A standard TUG test protocol was employed(29) whereby participants began seated, stood up, walked to and around a cone 3-metres away, and returned to a seated position. Participants were asked to complete the movement as quickly and safely as possible, refraining from using their arms for assistance during the chair rise, thus relying predominantly on the lower limbs for task completion. The movement was performed three times and the time to complete each trial was recorded using a stopwatch. To assess STS performance, participants began seated, and when ready stood up at their comfortable speed. Sagittal plane kinematics were measured at 100Hz (Qualisys, Sweden) to determine the time taken to complete one STS cycle. Movement initiation was defined as an increase in hip flexion of >1% of the maximum hip flexion during the movement (exhibited as increased forward trunk lean) that was shortly followed by knee extension. Maximum knee extension determined movement termination. Gait speed was derived from gait analysis data reported previously for the same sample(27). Briefly, 8-10 trials were collected while participants walked along a 10-metre walkway at a comfortable pace. Steady-state gait speed was obtained from the central part of the walkway and averaged across trials.

Knee flexor and extensor concentric strength were assessed bilaterally using dynamometry across the participants' full range of knee motion while the hip was flexed at 90° (Biodex System 3, Biodex Medical, Shirley, NY). Straps were secured around the trunk and hips for stability. The knee axis of rotation was aligned with the dynamometer axis of rotation and the dynamometer lever arm was secured to the distal end of the shank. Five practise trials were performed. Gravity corrected joint moments were recorded while participants performed maximal voluntary concentric contractions during five consecutive knee extension-flexion trials. Verbal encouragement was provided throughout. The angular speed of 180°/sec has been used previously with older adults(20) and concentric exercises have been shown to elicit significantly less cardiovascular stress than eccentric testing(30). Therefore, concentric testing at a high angular speed was chosen to minimise cardiovascular stress and avoid potential injury(31). The SF-36 is regarded as a generic measure of health status(17). The survey is comprised of 36 questions covering both physical and mental health, each of which is composed of 4 sub-scales. Administration of each test was standardised to the following order: TUG test, STS, knee strength, gait speed and SF-36, as the first two assessments served as a whole body warm-up prior to strength testing.

DATA ANALYSIS

The fastest TUG time from the three trials obtained was selected for further analysis(32) permitting task familiarisation. The time taken to complete a single STS cycle comfortably was used. Knee moments were normalised to body weight (Nm/kg). The hamstrings-to-quadriceps (H:Q) ratio was calculated from the peak joint moments. Paired-samples t-tests indicated that no significant strength differences existed between the right and left limbs so were combined for all analyses.

The SF-36 was analysed according to the 8 sub-scales: Physical Functioning, Role limitations due to physical health problems (Role–Physical), Bodily Pain, General Health, Vitality, Social Functioning, Role limitations due to emotional problems (Role–Emotional), and Mental Health(33). In the event of missing data, scores were estimated per participant by averaging the answers given within the section of questions with missing data(33). Of the 1404 questions (36 questions, 39 participants) only 30 data points were missing for nine participants. For seven participants, missing data were estimated and two participants were excluded from further analysis (n=37 remaining). Linear transformations were computed to transform SF-36 scores into z-scores using the norm-based scoring procedure according to the currently available normative database of the 1998 general US population(34). Each of the sub-scales was aggregated using a T-score transformation to produce a Mental Component Summary (MCS) and a Physical Component Summary (PCS).

Each of the outcome measures presented were chosen for their reliability and suitability for use with older adults. Intra-class correlation coefficients(ICCs) indicate how consistent or reproducible a quantitative measurement is. For example, the TUG time offers high reproducibility with an ICC of 0.8 from a cohort of older people(35) and similar levels of consistency has been confirmed for STS(6). Mechanical reliability of the dynamometer is high(ICC=0.99) as is test re-test reliability of strength in older adults(ICC>0.92)(36). Respectable ICCs have also been presented for the gait speed of older adults(ICC=0.74)(5) and across the age continuum incorporating both young and old(ICC=~0.9)(2). Finally, the SF-36 is suitable for use with older populations and demonstrates good construct validity with Cronbach's alpha statistics ranging from 0.82 to 0.94 for each of the subscales(17).

STATISTICAL ANALYSIS

Aim 1 – Estimation of annual changes in health and physical function

Bivariate correlations (Pearson's r) expressed the strength of the relationship between each of the outcomes and age. Linear regression was computed for all outcomes using age as a single independent predictor. Dependent variables were plotted against age to check for linearity and statistical assumptions surrounding regressive procedures were confirmed. Outliers were determined from the standardised residuals and data ±3SD from the mean were considered to be extreme and unlikely to have occurred by chance therefore they were removed(37, 38). For completeness, models excluding outliers are presented within the table and models with outliers included are presented within the footnotes of the table. R^2 (%) and the standardised regression coefficient (beta) are presented. Using the 75th percentile as a starting value, the annual change in function was calculated. 95% confidence intervals (95%CI) assessed the variation in estimated annual change.

Aim 2 – Changes in objective and self-reported physical function

Additional bivariate correlations were calculated between each of the objective and self-reported outcomes. Significance was accepted when $p \leq .05$.

RESULTS

Aim 1 - Estimation of annual changes in health and physical function

Five of the participants (aged 75, 78, 80 and two 83year olds) were unable to achieve the constant target velocity of 180°/s during the knee flexion dynamometry, and thus data for these individuals were removed from further analysis of flexion moments and H:Q ratio only. All of the objective assessments, with the exception of the STS, were significantly correlated with age ($p \leq .01$,Table 1,Figure 1). All significant relationships, except for TUG time, were negatively correlated with age (r=-.46 - -.58,$p \leq .05$). Strong negative correlations existed between age and knee strength measures (peak moments and H:Q ratio) and gait speed (r=-.46 - -.58,$p \leq .05$). The strongest negative correlations were found between age and knee moments (r=-.58,$p \leq .01$). Only the Physical Functioning sub-scale and PCS of the SF-36 were correlated with age (r=-.53 and -.38, respectively, Figure 2). Age contributed to explaining moderate-to-good levels of variance in all objective outcomes, except for STS time (R^2=21-34%, Table 1). Significant point estimates (B) were found for all of the objective outcomes, except for STS, revealing annual changes of 1.2-3.0%/year. Age explained the greatest variance in the knee extensor (R^2=33%) and flexor (R^2=34%) moments.

Age contributed to explaining moderate-to-good levels of variance in the Physical Functioning sub-scale and PCS (R^2=28% and 14%, respectively) with self-reported losses of 1.2%/year and 0.9%/year, respectively. Knee flexor moments exhibited the greatest decline (3.0%/year), although 95%CI were wider for the knee strength measures compared to self-rated Physical Functioning (±1.3%) and the PCS (±1.5%). Regression analysis could not be computed with a number of SF-36 subscales, as the majority of the sample attained the maximum score (100) demonstrating that a ceiling effect had occurred: Role–Physical and Social Functioning (both n=29,74% of the sample) and Role–Emotional (n=32, 82% of the sample).

TABLE 1 Regression models developed to explain the variance in the outcome measures explained by advancing age

		MEAN (SD)	Correlation with Age (r)	R^2 (%)	REGRESSION COEFFICIENT beta	Sig.	95% CI	ANNUAL CHANGE (%/year)	95% CI ANNUAL CHANGE
FUNCTIONAL MEASURES	TUG time (s) [1]	7.85 (2.9)	.53	28%	.181	p = .001	.084 : .277	*+2.1%*	*1.0 : 3.3%*
	STS time (s)	1.46 (0.26)	.15	0%	-.085	.386			
	Gait speed (m/s)	1.28 (0.20)	-.57	32%	-.017	p ≤ .001	-.026 : -.009	*-1.2%*	*-1.9 : -0.6%*
	HQ Ratio (%)	0.40 (0.15)	-.46	21%	-.010	p ≤ .001	-.017 : -.003	*-2.0%*	*-3.4 : -0.6%*
	Peak Knee Extensor Moment (Nm/kg)	0.48 (0.18)	-.58	33%	-.014	p ≤ .001	-.021 : -.007	*-2.2%*	*-3.5 : -1.0%*
	Peak Knee Flexor Moment (Nm/kg)	0.21 (0.11)	-.58	34%	-.009	p ≤ .001	-.014 :-.004	*-3.0%*	*-4.7 : -1.3%*
SELF-REPORTED MEASURES	SF36: Physical Functioning	81.7 (15.5)	-.53	28%	-1.143	p ≤ .001	-1.762 : -.525	*-1.2%*	*-1.9 : -0.6%*
	SF36: Role- Physical	84.2 (31.0)	-.19	^	^	^			
	SF36: Bodily Pain	77.4 (17.4)	-.30	9%	-.835	.065			
	SF36: General Health	73.4 (15.8)	-.21	10%	-.685	.059			
	SF36: Vitality	70.1 (16.9)	-.29	9%	-.770	.074			
	SF36: Social Functioning	93.8 (12.9)	-.03	^	^	^			
	SF36: Role – Emotional	92.1 (21.1)	-.11	^	^	^			
	SF36: Mental Health [2]	84.1 (10.3)	-.06	0%	-.105	.701			
	SF36: Mental Component Summary [3]	56.6 (5.1)	.01	0%	.008	.958			
	SF36: Physical Component Summary	50.3 (8.5)	-.38	14%	-.443	.022	-.801 : -.065	*-0.9%*	*-1.6 : -0.1%*

^ indicates variables where regression could not be computed due to ceiling effects, CI denotes confidence interval, HQ: Hamstrings-to-Quadriceps Ratio.

Footnotes indicate the models with outliers included within the model
[1] Regression model: Age, TUG time - R^2 = 29%, Beta coefficient = 0.121, p = .121
[2] Regression model: Age, Mental health: - R^2 = 4%, Beta coefficient = 0.270, p = .267
[3] Regression model: Age, MCS: R^2 = 1%, B = -0.086, p = .524

Aim 2 – Changes in objective and self-reported physical function

Cross-correlations between the outcomes revealed that TUG time strongly correlated with knee strength (*r*=-.55 - -.68,p≤.01;Table 2) and was highly correlated with speed (*r*= -.83,p≤.01). TUG time was negatively correlated with many of the physical SF-36 sub-scales and the PCS (*r*≥ -.40,p≤.05). STS correlated well with TUG time (*r*=.38,p≤.05) and gait speed (*r*=-.35,p≤.05) but was not correlated with knee strength. Like TUG time and gait speed, STS time was moderately correlated with many of the SF-36 subscales (*r*=-.41 - -.54,p≤.01). Gait speed was positively correlated with many of the SF-36 variables (*r*=.41-.63,p≤.05) including all of the physical components.

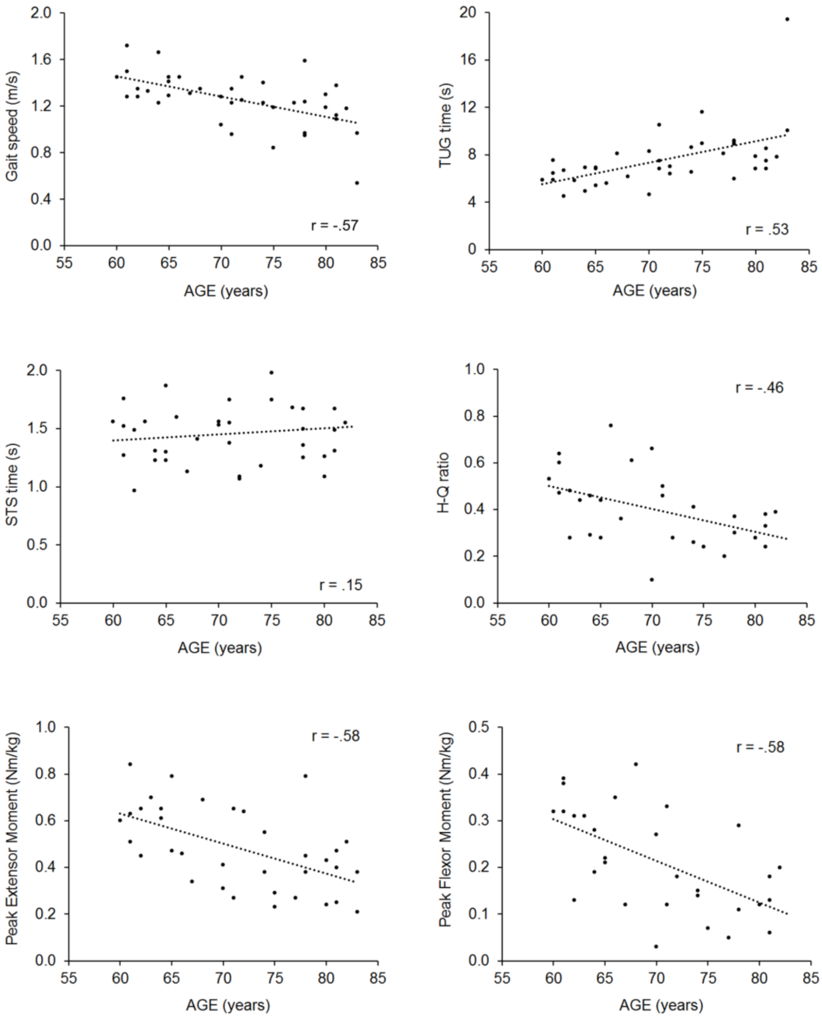

FIGURE 1 Relationships (*r*) between age and the functional outcome measures studied

For completeness graphs are presented with outliers, ** p ≤ .01 (1-tailed), and *** p ≤ .001 (1-tailed)

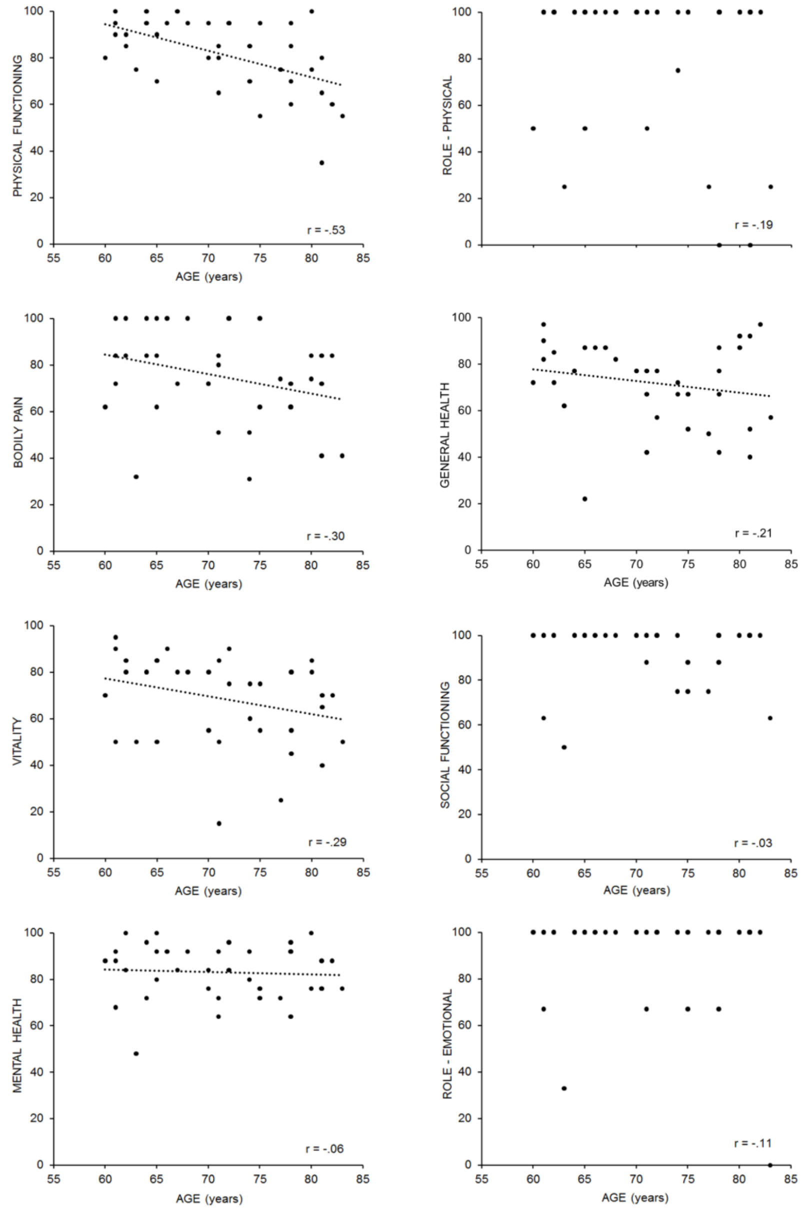

FIGURE 2 Relationships (*r*) between age and the eight (physical and mental) sub-scales of the SF-36

For completeness graphs are presented with outliers, * p ≤ .05

TABLE 2 Correlation matrix (r) between all outcome measures studied

		TUG time (s)	STS time (s)	Gait speed (m/s)	HQ ratio (%)	Peak Knee Extensor Moment (Nm/kg)	Peak Knee Flexor Moment (Nm/kg)	SF-36 PF	R-P	BP	GH	VT	SF	R-E	MH	MCS	PCS
FUNCTIONAL MEASURES	TUG time (s)		.38	-.83	-.55	-.57	-.68	-.58	-.27	-.40	-.43	-.49	-.30	-.40	-.29	-.31	-.47
	STS time (s)	-		-.35	-.07	-.18	-.12	-.46	-.34	-.43	-.28	-.46	-.54	-.45	-.50	-.50	-.41
	Gait speed (m/s)	-	-		.46	.67	.67	.63	.33	.44	.41	.49	.25	.41	.27	.27	.52
	HQ ratio (%)	-	-	-		.30	.82	.44	.26	.32	.46	.35	.03	-.08	.12	-.04	.45
	Peak Knee Extensor Moment (Nm/kg)	-	-	-	-		.76	.35	.07	.15	.09	.23	.07	.02	.03	.00	.21
	Peak Knee Flexor Moment (Nm/kg)	-	-	-	-	-	-	.53	.18	.35	.48	.31	.15	-.12	.01	-.14	.47
SELF-REPORTEDMEASURES	SF36: Physical Functioning	-	-	-	-	-	-		.71	.74	.55	.55	.34	.60	.10	.12	.90
	SF36: Role – Physical	-	-	-	-	-	-	-		.69	.65	.68	.45	.63	.20	.29	.90
	SF36: Bodily Pain	-	-	-	-	-	-	-	-		.46	.55	.57	.64	.30	.34	.84
	SF36: General Health	-	-	-	-	-	-	-	-	-		.69	.28	.29	.33	.27	.71
	SF36: Vitality	-	-	-	-	-	-	-	-	-	-		.51	.40	.57	.59	.65
	SF36: Social Functioning	-	-	-	-	-	-	-	-	-	-	-		.74	.57	.84	.42
	SF36: Role – Emotional	-	-	-	-	-	-	-	-	-	-	-	-		.22	.59	.64
	SF36: Mental Health	-	-	-	-	-	-	-	-	-	-	-	-	-		.84	.11
	SF36: Mental Component Summary	-	-	-	-	-	-	-	-	-	-	-	-	-	-		.17
	SF36: Physical Component Summary	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	

HQ: Hamstrings-to-Quadriceps Ratio, PF: Physical Functioning, R-P: Role-Physical, BP: Bodily Pain, GH: General Health, VT: Vitality, SF: Social Functioning, R-E: Role-Emotional, MH: Mental Health,
Light grey shading indicates moderate correlations r = 0.4-0.6 p < .05, and dark grey shading indicates strong correlations r = 0.7-1.0 p < .05.

DISCUSSION

This study used linear regression to quantify the changes in objective and self-reported function that were attributable to age alone. This is a novel approach that furthers our understanding beyond that of previous studies which have assessed functional loss using a single clinical assessment (2, 3, 21, 24, 25, 39) or a battery of assessments according to broad pre-defined age groupings (1, 3, 40-42). This study found that the pattern of age-related functional losses can be estimated using linear regression, thereby enhancing our understanding of the rate of decline throughout older age. Furthermore, large within-group variability (represented by the standard deviation) was observed for many of the outcomes presented, indicating that categorising individuals across large age ranges, as has been common in previous research(43, 44), leads to considerable variation and limited information about age-related functional decline.

Aim 1 - Estimation of annual changes in health and physical function

Overlapping 95%CI for estimated annual changes in all of the objective outcomes (except for STS) and the Physical Functioning and Physical Component Summary of the SF-36 (Table 1) indicate that gradual losses due to biological ageing processes appear to occur at similar rates for which age has been shown to explain significant variation (R^2=14-34%). This is in agreement with previous research demonstrating that age was a major contributor, explaining significant variation in TUG time (R^2=60%),gait speed (R^2=63%) and timed STS (R^2=37%)(1). While the convenience sample in that study(1) showed gradual decline over a large age range (66-101years), both men and women were tested which may have affected the point estimates due to gender differences in musculoskeletal function/capacity(5, 6) and relative life expectancy(8). Our study has demonstrated that significant annual losses in function occur within a cohort of healthy older women and further analyses should be repeated with men for comparison. To our knowledge, Lusardi et al.'s study(1) is the only study that has taken a similar approach to understanding age-related decline in a battery of motor function indices. Other studies have quantified losses in a similar fashion, for musculoskeletal strength (45) but have not investigated relative annual decline for a range of functional characteristics.

It is noteworthy that greater age-induced losses were observed for the knee flexors compared with the extensors, and this is in agreement with longitudinal observations of older women(45). Those findings, along with our present data, indicate that the smaller flexor muscles experience greater strength losses compared to the larger anti-gravity extensor group. Accordingly, the point estimates presented in this study indicate that the hamstrings-to-quadriceps (H:Q) ratio reduced with age, with an annual loss of 2.0%. This suggests that the strength difference between this antagonistic pair became larger with age. Such declines may impact adversely on the ability to negotiate obstacles and stairs safely; execute postural transitions; bend down to a lower level; and ultimately knee joint stability. It should be noted that the knee flexion moments of five of the oldest participants were excluded from all analyses because they were unable to achieve the constant target velocity (isovelocity phase). This was despite multiple trials and verbal encouragement, and was most likely because they lacked muscle power to accelerate the dynamometer lever arm adequately. Consequently, the reported knee flexion moments for participants aged >75 years are likely overestimated compared to the population and the annual decline for knee flexion moment and H:Q ratio are likely underestimated. We consider this to further demonstrate the significant age-related weakness in the oldest old (particularly for knee flexor tasks). However, even at the magnitudes observed considerable losses were identified that in accumulation could restrict mobility and independent functioning. The expansion of this work to other antagonistic muscle pairs (hip and ankle) may help to define joint functionality and inform the nature of age-related reciprocal muscle strength loss. While the accumulated annual changes in knee strength with age are of clinical significance, it must be highlighted that in some cases, cross-sectional studies have reportedly underestimated strength losses compared to longitudinal research(45).

Interestingly, age explained moderate levels of variance in Physical Functioning and the PCS, which was of a similar magnitude to the measured physical decline observed in gait speed, TUG time and knee strength. Age did not explain significant variance in any other SF-36 sub-scale suggesting that some aspects of the SF-36 may reveal changes related to other factors such as personality type, or demonstrate inconsistencies due to individual perception. A self-reporting survey results in perceived ability and/or status rather than actual task performance, assessed objectively. Although self-reporting general health scales have been suggested to predict functional decline accurately(46), the under- or over-reporting of physical status has been linked to personality traits and levels of self-awareness(47). This study has shown that, in a sample of healthy older women with no prior falls history, self-reported function estimated measured performance very accurately. We found the same annual loss for gait speed and for the Physical Functioning sub-scale of the SF-36 (1.2%/year). 95%CI overlapped for these variables and were small, indicating that within this cohort the changes were predicted very precisely. This was likely indicative of the participants' good health and independent living status.

In summary, accumulative losses in function have been demonstrated in the current study. The year-on-year changes in function presented may appear to be small and thus not clinically significant. However, when considering the accumulation of these changes across several years and in relation to critical thresholds proposed within the literature (For example, gait speeds of <1.0m/s(48) and TUG times of >14s(13)) the optimal time to intervene may be planned to attenuate losses before overall function is affected clinically. Larger population-based studies are required to substantiate the declines presented in this study and then national databases may be developed and used to monitor functional/ global health changes to estimate demographic health and future costs.

Aim 2 – Changes in objective and self-reported physical function

Using gait speed as a clinical outcome is advantageous due to its high test-retest reliability(2, 5), as well as the significant correlations other outcomes(1) and deterioration with age(2). This study found that that in addition to speed, TUG time reflects the functional declines in many ADL. In fact, utilising the TUG test in clinical practice may be advantageous due to the limited space/ equipment and expertise required compared with the space required to attain, and record speed from, steady-state gait. However, both of these objective outcomes should be included routinely as part of a normal health check-up and physical assessment of older women. Reduced performance on these outcomes may be caused by declining knee extensor strength which contributes heavily to both measures (lower limb stability and forward continuance during level gait; and raising the body from a seated position). Measured leg strength is not currently included on the list of validated measures provided by the CSP. This is likely due to the dynamometry equipment and technical expertise required for data acquisition. A viable compromise may include quantifying muscle strength manually given its widespread use within a clinical setting(49, 50). Reliable, valid data may be obtained from such measures(51, 52) providing that recommendations such as those proposed by the International College of Applied Kinesiology are adhered to(53). However, extra care must be taken when constructing controlled testing conditions for use with large age ranges given that some of the oldest individuals appear unable to perform at higher joint angular velocities. Furthermore, slower gait speeds may result from age-associated muscle weakness(54), and more specifically knee extensor strength loss (as indicated by the findings in this study). Therefore, reduced functioning when standing from sitting (TUG) combined with deteriorating gait speeds, both relatively simple measures to obtain, may provide an early indication of knee extensor weakness which consequently will adversely affect overall physical function. To this end, measures of gait speed and TUG time proved to be informative markers indicative of functional decline, related most strongly to performance across a range of ADLs, and thus should continue to be collected as part of routine assessment in outpatients, clinics and physiotherapy/ rehabilitation.

Measuring STS performance did not reveal functional losses above and beyond that of comfortable gait speed, TUG time and knee strength. Thus, performing the STS is unlikely to further enhance our understanding of annual musculoskeletal changes in performance when used in combination with other outcomes. Rarely, do we perform a single postural transition in isolation and STS time may be criticised for its lack of ecological validity. Moderate correlations were observed between STS time and some of the psychological subscales of the SF-36 and the role of psychological status and STS time has been confirmed previously(55).

The results of this study emphasise that there was a continuous decline in function throughout older age. These musculoskeletal losses occurred even in a sample of healthy older women, for whom functional decline appeared to be linear. Gait speed and TUG time were reaffirmed as markers indicative of functional decline and related most strongly to performance across a range of ADLs. Considering their cost- and time-effectiveness and strong correlation with many other outcomes, gait speed and TUG should be incorporated into routine clinical and geriatric assessments starting from middle-age as declines occur in even healthy older women beyond 60 years of age. The significant correlations between H:Q ratio and TUG time (r=-.55) and gait speed (r =.46) further substantiate their suitability for clinicians to obtain during routine assessments with older adults. However, because knee flexor strength does not contribute to TUG time and gait speed as much as extensor strength, additional assessments may be required to identify flexor strength and H:Q ratio losses. The predicted yearly decline in knee flexor strength, which was greater than for the knee extensors, has important implications for the safe execution of many functional tasks which may not be otherwise highlighted by losses in gait speed and TUG time alone. Consequently, this should be addressed in exercise interventions for older adults, as the knee flexors may be ‘neglected’ in primarily anti-gravity based exercises.

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